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Introducing a Flipped Classroom for a Statistics Course: a Case Study

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***Abstract* — One of the novel ideas in teaching that heavily relies on current technology is the "flipped classroom" approach, or "inverse teaching". In a flipped classroom the traditional lecture and homework sessions are inverted. Students are provided with online material in order to gain necessary knowledge before class, while class time is devoted to clarifications and application of this knowledge. The hypothesis is that there could be deep and creative discussions when teacher and students physically meet. This has inspired an experiment utilizing this approach in a statistics course for fourth semester students in a Bachelor program in Media Technology. The results of the experiment revealed some strengths and weaknesses of this instructional model. We conclude that the flipped classroom can be beneficial for students, provided that it is based on a careful design.**

***Keywords*— Mathematics education, statistics, flipped classroom, technology-enhanced learning, problem-based learning, media technology**

I. Introduction

Active learning is an instructional method that focuses on engaging learners and making them responsible for their own learning. Bonwell and Eison defined this approach to instruction as "…anything that involves students in doing things and thinking about the things they are doing." [1]. Active learning therefore embraces different instructional models, in which learners are engaged in other activities than just listening – they are encouraged to read, write, discuss and be involved in higher-order thinking.

One of the recent developments in teaching, which is also a form of active learning, is the flipped (or inversed) classroom approach [2]. In a flipped classroom the traditional lecture and homework sessions are inverted. Students are provided with online material in order to gain necessary knowledge before class, while class time is devoted to clarifications and application of this knowledge. The course content, which is provided for self-study, may be delivered in the form of video casts and/or pre-class reading and exercises, while class time is mainly used for group work activities. The hypothesis is that there could be deep and creative discussions when the teacher and students physically meet. This teaching and learning approach endeavours to make students owners of their learning trajectories, and relies heavily on current technology.

Surveys in the literature commenting on strengths and weaknesses of this new teaching approach have appeared the last several years. Herreid and Schiller in [3] combined their findings from a survey of the 15,000+ members of the National Center for Case Study Teaching in Science Listserv with Kathleen Fulton's paper [4] and compiled the following list of advantages of the flipped classroom: (1) students can learn at their own pace; (2) doing assignments in class gives teachers better insight into student difficulties; (3) teachers can more easily customize and update the curriculum; (4) classroom time can be used more effectively and creatively; (5) teachers using the method report seeing increased levels of student achievement, interest, and engagement; (6) learning theory supports the new approaches; (7) the use of technology is flexible and appropriate for "21st century learning"; (8) there is more time to spend with students on authentic research; (9) students get more time working with scientific equipment that is only available in the classroom; (10) students who are absent can still watch the lectures; (11) the method "promotes thinking inside and outside of the classroom"; and (12) students are more actively involved in the learning process.

Along with advantages, Herreid and Schiller noted also the following weaknesses of flipped learning: (1) Students new to the method may be initially resistant because it requires that they do work at home rather than be first exposed to the subject matter in school. Consequently, they may come unprepared to class to participate in the active learning phase of the course and (2) the homework (readings, videos) must be carefully tailored for the students in order to prepare them for the in-class activities. However, teachers reported that finding or creating good quality videos is difficult. The quality of the teacher-created videos is reported to be often marginal and creating them requires a significant amount of time.

In this paper, we present our efforts to implement a flipped classroom for a statistics course at the Media Technology Department at Aalborg University Copenhagen, Denmark. Mathematics courses are challenging for Media Technology students. The problems these students face are easily generalizable to many students – they come to the statistics class lacking basic skills in mathematics and motivation. We hypothesized that a flipped classroom would allow these poorly achieving students to work on lesson preparations at their own pace, empowering them to ask relevant questions during class. Our results showed that a flipped classroom has both pros and cons, yet it can benefit students when it is carefully designed.

II. LITERATURE REVIEW

Various researchers and instructional designers have sought to investigate the advances in flipped learning environments. Kay and Kletskin introduced problem-based video podcasts covering key areas in mathematics. The video podcasts were created as self-study tools, and used by higher education students to acquire pre-calculus skills [5]. The results indicated that a majority of students used the video podcasts frequently, viewed them as easy to use, effective learning tools, rated them as useful or very useful, and reported significant knowledge gains in pre-calculus concepts.

Love and Hodge compared a classroom using the traditional lecture format with a flipped classroom during an applied linear algebra course [6]. Students in the flipped classroom environment had a significant increase between the sequential exams compared to the students in the traditional lecture section, but they performed similarly in the final exam. Moreover, the flipped classroom students were very positive about their experience in the course, and particularly appreciated the student collaboration and instructional video components.

Bates and Galloway conducted a practice-based case study of curriculum redesign in a large-enrolment introductory physics course. The course followed a flipped classroom approach and the results of their study show evidence for high quality learning [7].

Enfield applied a flipped classroom model of instruction in two classes of a course focusing on web design [8]. Student reports suggested that the approach provided students with an engaging learning experience, was effective in helping students learn the content, and increased self-efficacy in their ability to learn independently.

While the aforementioned approaches report on benefits of the flipped classroom, there are also critics to this approach [9-11]. Concerns include among others: criticism about the accessibility to online instructional resources, the growing move towards no homework, increased time requirements without improved pedagogy, teachers concerns that their role will be diminished, lack of accountability for students to complete the out-of-class instruction, poor quality video production, and inability to monitor comprehension and provide just-in-time information when needed.

Taking into consideration the reported strengths and weaknesses, we decided to introduce this instructional model to a statistics course, with the aim to investigate if a flipped classroom would benefit Media Technology students in mathematics.

III. METHODOLOGY

Our research was conducted at the Media Technology Department of Aalborg University Copenhagen. Aalborg University implements a Problem Based Learning (PBL) teaching and learning model since its foundation [12]. This model encourages active learning and is combined with group work. Therefore, it provided a proper test bed for our experiment.

The program in Media Technology is a trans-disciplinary educational program with a focus on research which combines technology and creativity. The teaching of mathematics to Media Technology students is a challenge; typically these disciplines are more related to arts and humanities, and constructed in specific opposition to the technology and science. The typical student lacks basic skills in mathematics and does not easily relate to the standard applications of mathematics (for example in science and economy) mentioned in textbooks [13]. These students often do not approach or perceive mathematics the same way as mathematics students do, moreover mathematics can be used in a different ways in creative disciplines when compared to science.

The Flipped Classroom model of instruction was implemented in a statistics course (106 fourth-semester students in total) during the spring 2013 semester. To facilitate this, 16 video casts were created to provide students with instruction outside of the classroom. These instructional videos were created by the researchers and were combined with assigned readings and videos from online sources. In-class assignments were provided along with each lesson. We implemented the flipped instructional model in the first part of the course, where mathematical knowledge students should already have is recapitulated.

The learning process generally followed the same sequence. Prior to class, students were expected to watch the related video lessons. During class, a question round took place, in order to clarify aspects that students found challenging. Then, students were provided in-class assignments to reflect on, discuss, and practice what they had learned. The classroom activity was mainly not teacher led; instead, students in groups worked on the assignments while the instructor provided individual guidance as needed. The in-class activities were structured so as to provide students with a variation of the tasks they completed when watching the video, providing opportunity for both practice and transfer of learning to new situations. Additionally, some activities were teacher led demonstrations. Since students were expected to already know some content from previous mathematics courses, the teacher was calling on individuals to explain what to do to complete the task.

Data was collected pre- and a post-test, and through a survey at the end of the “flipped” lectures. Both tests were multiple choice tests, which contained questions similar to the in-class assignments. The survey used a Likert scale in order to collect student responses in regards to the instructional videos assigned for out-of-class preparation, the in-class instructional activities, and the more general impact the course had on students. Items in the survey were measured using 5-point rating scales, with the range of answers from “strongly disagree” to “strongly agree.” Moreover, there were three items, which gave students the opportunity to provide further information in an open-ended manner (“What were the strengths of the video casts?’, “What were the weaknesses of the video casts?”, and “Do you have any other comments or suggestions?”).

IV. RESULTS

At the beginning of the semester 106 fourth-semester students took a pre-test on mathematics knowledge that they should have already, as it was taught in previous semesters. The results of the post-test are shown in Table 1. Only 9.43% of the students could pass the pre-test and the average score was quite low (39.9 out of 100). At the end of the flipped classroom part of the course, the same students were given a post-test, which was similar to the pre-test. The results of the post-test are shown in Table 2. This time 62.14% of the students passed the test, and their average score was higher (66.25 out of 100).

TABLE I
STATISTICS ON RESULTS OF PRE-TEST

	N = 106
Mean Score (out of 100)	39.9
SD	17.0
Passed (%)	9.43
Failed (%)	90.6

TABLE II
STATISTICS ON RESULTS OF POST-TEST

	N = 106
Mean Score (out of 100)	66.25
SD	16.0
Passed (%)	62.14
Failed (%)	37.86

At the end of the lectures, a survey was also distributed in order to investigate how students evaluated the new instruction model. 104 students completed the survey and the results are given in Fig. 1 – 8.

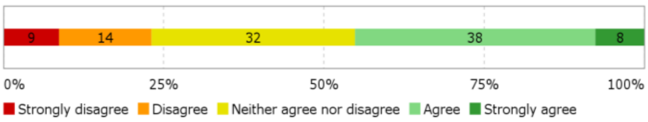

Fig. 1 This course has improved my learning

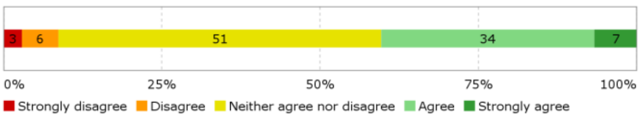

Fig. 2 The video casts were helpful

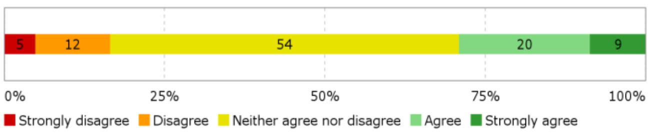

Fig. 3 I would rather watch a traditional teacher led a lesson than a video cast

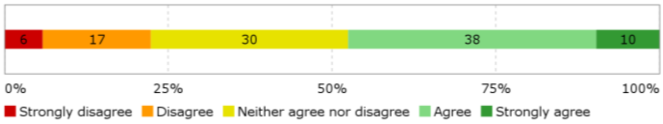

Fig. 4 I felt motivated to learn mathematics during this course

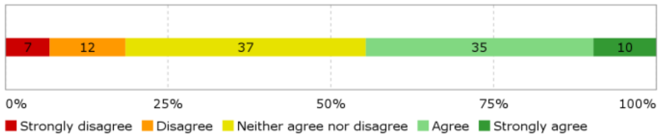

Fig. 5 I like the idea of studying related theory alone before lectures and then doing assignments during lectures

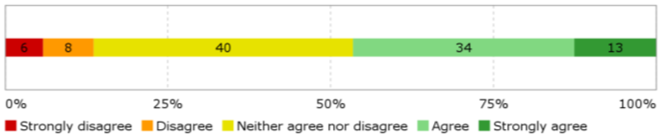

Fig. 6 I feel that the idea of studying related theory alone before lecture, and doing assignments during lectures enhances learning

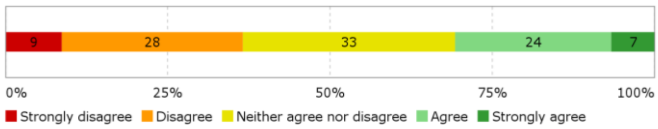

Fig. 7 This course was more engaging than traditional classroom instruction

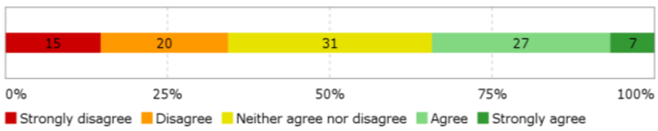

Fig. 8 I watched most of the video casts

The results of the survey show that 46.1% of the students agreed or strongly agreed with being motivated during the course and 44.2% with having improved their learning during the course, while 22.1% disagreed or strongly disagreed with these statements. Moreover, 45.2% of the students agree or strongly agree that the flipped classroom enhances learning, while 43.3% stated that they liked this idea. The percentages of students that disagreed or strongly disagreed with these statements are 13.5% and 18.3% respectively.

Regarding the video casts, 39.4 % of the students found them useful while 8.7% disagreed or strongly disagreed with that. 32.7% stated that they watched most of them (percentages of “agree” or “strongly agree”), while 33.6% stated that they didn’t (percentages of “disagree” or “strongly disagree”).

Finally, 27.9% of the students said that they would rather watch a traditional teacher led a lesson than the video casts while 18.3% disagreed with that statement. Regarding how engaging the flipped classroom was, 29.8% found it more engaging than traditional classrooms and 35.6% did not.

In all items of the survey, the results show high percentages of "neither agree nor disagree" answers (28.9 – 51.9%).

In the responses to open-ended items, being able to replay the whole video or parts of it many times and being able to learn at your own pace were the dominant strong points of the video casts. Regarding their weak points, the students mentioned that not being able to ask questions while watching the video casts was the main drawback.

V. CONCLUSIONS AND DISCUSSION

According to the results of the pre- and post-tests presented in the previous section, the students were able to significantly improve their performance in mathematics during the flipped classroom. While the percentage of students who failed the post-test is relatively high, this can be explained by the extremely high number of students, who failed the pre-test.

Regarding the instructional videos assigned for out-of-class preparation, our results showed that students find them helpful and they appreciate the fact that they no longer struggle with challenging concepts alone and they can skip or re-watch parts of the lesson. Nevertheless, less than half of them watched most of them and they mentioned as a weakness the fact that they cannot ask questions for clarification during a recorded lesson.

As far as the more general impact the course had on students, they stated that it improved their learning and they felt motivated, but at the same time they did not perceive it as engaging. In general, the students liked this new approach and they think that it can enhance learning.

The high percentages of neutral answers ("neither agree nor disagree") indicate that students do not have strong opinions on the flipped classroom approach. This might be attributed to the fact this approach is new to students, as they probably need more time in order to form strong opinions.

Combining students' feedback and our own reflections on this new instructional model, we created a list with pros and cons shown in Table 3.

TABLE III
STRENGTHS AND WEAKNESSES OF A FLIPPED CLASSROOM

Strengths	**Weaknesses**
Students can skip parts of the lesson that they are familiar with and re-play parts that they find challenging.	Difficult for students to change their old habits regarding instruction and lesson preparation.
Videos may provide material for deeper thinking.	Hard to create or find quality videos.
Teachers can work with small student groups.	Creating videos is time consuming.
Students are given responsibility for their own learning.	Students not able to ask clarification questions while watching the videos.
It is possible to differentiate instruction according to individual needs.	Difficulties to cope with students who come to class unprepared.
Active learning in classroom.	
Encourages collaboration between students.	

Based on our observations and the results of our study, we conclude that a flipped instructional model has to be carefully designed in order to be beneficial. A careful design has to attempt to eliminate the weaknesses of such a model, and to better customize it to the context. Since it is a relatively new approach, we believe that it will gain ground in the future, once teachers and students become more familiar with it.

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